Technical Support Document
for EPA's Multi-Pollutant Analysis

Methods for Projection Health Benefits for EPA's Multi-Pollutant Analyses of 2005

October 2005

Prepared by:
Office of Air and Radiation
U.S. Environmental Protection Agency

This technical support document is part of a comprehensive EPA analysis of various multi-pollutant proposals that have been introduced in the Senate. The proposals are designed to reduce emissions from the power sector, and EPA has agreed to perform detailed modeling for five legislative proposals and to present that information along with modeling results of EPA's recent regulatory approach to reducing emissions from the power sector. The analysis is based on air quality, health benefits, and power sector modeling projections and estimates for each proposal for the years 2010, 2015, and 2020. The following proposals and regulations were analyzed (shorthand identifiers used for each run in this document are identified in quotes):

1. The Clean Power Act (Jeffords S.150 in 109^{th}; "Jeffords")
2. The Clean Air Planning Act (Carper S.843 in 108^{th}; "Carper")
3. The Clear Skies Act of 2005 (Inhofe S.131 in 109^{th}; "Inhofe")
4. The Clear Skies Act of 2003 (Inhofe, S.485 in 108^{th}; "CSA 2003")
5. The Clear Skies Act of 2005 (Manager's Mark of S.131 in 109^{th}; "CSA MM")
6. The Clean Air Interstate Rule, The Clear Air Mercury Rule, and The Clean Air Visibility Rule (EPA promulgated rules, 2005; "CAIR/CAMR/CAVR")

This technical support document reports the methods for projecting benefits for EPA's multi-pollutant analysis. Detailed air quality modeling was completed for three of these multi-pollutant scenarios: Inhofe, Carper, and CAIR/CAMR/CAVR. The human health benefits (both the number of incidences of health effects avoided and the monetary savings from those avoided incidences) for fine particles and ozone were calculated with the BenMAP model. This was done following the protocols used for the final Clean Air Interstate Rule (published March 10^{th}, 2005). Information on these methods can be found in Chapter 4 of the Regulatory Impact Analysis for the Final Clean Air Interstate Rule (EPA-452/R-05-002, March 2005). This information is available on the internet at http://www.epa.gov/cair/technical.html#final. The BenMAP model and documentation is available on the internet at: http://www.epa.gov/ttn/ecas/benmodels.html.

In order to provide estimates of the health benefits associated with the three multi-pollutant scenarios for which no air quality modeling was conducted (referred to hereafter as interpolated/extrapolated scenarios: S.150 Clean Power Act (Jeffords scenario); Clear Skies Act Managers Mark (CSA MM scenario); and S.485 Clear Skies Act of 2003 (CSA 2003 scenario)), EPA used a systematic extrapolation procedure consisting of several elements.

First, EPA compared emission reductions patterns for SO_2, NO_x, and direct fine particulate matter ($PM_{2.5}$) between modeled and interpolated/extrapolated scenarios in three model years (2010, 2015, and 2020). Each interpolated/extrapolated scenario was matched to the modeled scenario that had the fewest geographic dissimilarities in the pattern of emission reductions over all three model years.

To estimate the health benefits associated with changes in $PM_{2.5}$, EPA

1. Generated estimates of the population-weighted change in three primary components of $PM_{2.5}$ concentration (sulfate, nitrate, and direct $PM_{2.5}$) for each paired modeled

scenario using the sum over the model grid cells of each change in $PM_{2.5}$ times the population in that grid cell/total U.S. population. (see Table 1). This resulted in a change in concentration of the three $PM_{2.5}$ components in population-weighted average micrograms.

2. Calculated the ratio of population-weighted concentrations of ammonium sulfate, ammonium nitrate, and direct $PM_{2.5}$ to their primary indicator emissions (SO_2, NO_x, and direct $PM_{2.5}$, respectively) (see Table 2). This resulted in a measure of the impact on the three population-weighted $PM_{2.5}$ components in micrograms per ton of emissions reduced.

3. Multiplied the microgram per ton estimates for each component by the amount of emissions reductions for each interpolated/extrapolated scenario to obtain estimates of the population weighted change in the components, and then summed the components to calculate a single change in population weighted ambient $PM_{2.5}$ concentrations.

4. Estimated $PM_{2.5}$ health benefits by multiplying the estimated changes in $PM_{2.5}$ (the sum of scaled changes in $PM_{2.5}$ species in #3 above) by the health benefits per microgram of $PM_{2.5}$ reduction (calculated by dividing the estimated benefits for the modeled scenario by the population weighted change in ambient $PM_{2.5}$ for the modeled scenario).

5. Steps 3 and 4 were repeated for each interpolated/extrapolated scenario in each model year (2010, 2015, and 2020)

To estimate the health benefits associated with changes in ozone, EPA:

1. Calculated the ratios of summer NO_x emissions from the matched modeled scenario to the interpolated/extrapolated scenario (see Table 3).

2. Estimated ozone health benefits by multiplying the ozone health benefits for the modeled scenario by the summer NO_x emission ratio.

Finally, the total benefits were estimated as the sum of the scaled PM and ozone benefits.

Changes from base case to each multi-pollutant scenario in emissions of NO_x, SO_2 and direct PM expected to occur as a result of applying controls to meet the caps under alternative multi-pollutant bills were estimated using the Integrated Planning Model (IPM). The resulting state level emissions changes were compared between the three multi-pollutant scenarios for which air quality modeling was completed (Carper, Inhofe, and CAIR/CAMR/CAVR), and the three scenarios for which air quality modeling was not conducted (Jeffords, CSA MM, and CSA 2003). In addition to the overall level of emissions reductions, population weighted average air quality impacts (which are closely linked to health benefits) are closely tied to the geographic distribution of the emission reductions. As such, EPA matched the interpolated/extrapolated scenarios to a modeled scenario based on minimizing the differences in the state level distributions of reductions in NO_x and SO_2. Based on these comparisons, the Inhofe modeled scenario provided the closest match for both the CSA MM and CSA 2003 scenarios. The Carper modeled scenario provided the closest match for the Jeffords scenario.

The benefits extrapolation method used to estimate benefits for the interpolated/extrapolated multi-pollutant scenarios is similar to that used to estimate benefits in the recent analyses of the Nonroad Diesel rule and Large SI/Recreational Vehicles standards. A similar method has also been used in recent benefits analyses for the proposed Utility MACT standard[1].

The application of the Inhofe scenario to the CSA MM and CSA 2003 scenarios requires little extrapolation, as the emissions reductions in these scenarios are very similar. The extrapolation from Carper to Jeffords requires more extrapolation due to the much larger reductions in the Jeffords scenario relative to Carper. Population-weighted changes in total $PM_{2.5}$ and $PM_{2.5}$ component species were generated for each modeled scenario. The population-weighted changes in component species for the two modeled scenarios used for the extrapolations are summarized in Table 1.

Table 1. Population-Weighted Changes in $PM_{2.5}$ Component Species in Two Modeled Scenarios

Population-Weighted ug	2010	2015	2020
INHOFE			
Ammonium Nitrate	0.037	0.052	0.066
Ammonium Sulfate	0.691	0.740	0.883
Primary PM (EC+Crustal)	0.013	0.017	0.020
Total	0.741	0.809	0.969
CARPER			
Ammonium Nitrate	0.045	0.065	0.073
Ammonium Sulfate	1.163	1.042	1.073
Primary PM (EC+Crustal)	0.022	0.021	0.023
Total	1.23	1.128	1.169

[1]http://www.epa.gov/ttn/atw/utility/proposalutilitymactbenefitsanalysisfinal.pdf

The impacts of emissions changes on $PM_{2.5}$ component concentrations (in micrograms per ton emissions) were generated for each of the three component species by dividing the species-specific population-weighted change by the total tons of the indicator emissions species (see Table 2). For ammonium nitrate, the indicator emissions species is NO_x, for ammonium sulfate, the indicator species is SO_2, and for primary PM (EC + Crustal), the indicator species is direct $PM_{2.5}$ emissions. Note that EPA did not have exact estimates of the percent change in direct $PM_{2.5}$ emissions for the three interpolated/extrapolated scenarios. However, analysis of existing model runs indicates there is a relatively constant relationship between the percent reduction in SO_2 and the percent reduction in direct $PM_{2.5}$. For every 12 percent decrease in SO_2, there is a corresponding one percent decrease in direct $PM_{2.5}$. EPA uses this relationship to predict the decrease in directly emitted $PM_{2.5}$ for the three interpolated/extrapolated scenarios (see the accompanying Excel spreadsheet for documentation of how the direct PM emissions were calculated).

Table 2. Change in Population-Weighted $PM_{2.5}$ Component Species per Ton of Indicator Emissions Reduced

	Ammonium Sulfate/SO_2	Ammonium Nitrate/NO_x	EC and Crustal/Direct PM
Inhofe			
2010	1.844E-04	2.581E-05	8.667E-05
2015	1.934E-04	3.302E-05	8.873E-05
2020	1.988E-04	3.622E-05	8.866E-05
Carper			
2010	1.969E-04	2.571E-05	8.464E-05
2015	2.006E-04	3.311E-05	8.570E-05
2020	2.027E-04	3.629E-05	8.887E-05

Health benefits per microgram for each of the two modeled scenarios were generated by dividing the health benefits for each scenario by the corresponding population-weighted change in total $PM_{2.5}$ for the scenario in each analysis year.

The estimated change in total $PM_{2.5}$ for each interpolated/extrapolated scenario was calculated by multiplying the species-specific microgram/ton estimates (see Table 2) by the tons of indicator emissions reduced (SO_2, NO_x, or direct $PM_{2.5}$) for the target scenario. These values were then summed across the species.

Extrapolated $PM_{2.5}$ benefits for the three interpolated/extrapolated scenarios were then calculated by multiplying the benefits per microgram from one of the matched modeled scenarios times the estimated change in total $PM_{2.5}$ for its paired interpolated/extrapolated scenario. This was done for three model years: 2010, 2015, and 2020.

Table 3 provides the ratio of summer season NO_x in the modeled scenarios to the interpolated/extrapolated scenarios.

Table 3. Ratio of Summer NO_x Emissions Between Interpolated/Extrapolated Multi-pollutant Scenarios and Modeled Multi-pollutant Scenarios

Interpolated and/or Extrapolated Scenario/Closest Modeled Scenario	Ozone Season NO_x Ratio
CSA 2003/Inhofe	
2010	1.15
2015	1.15
2020	1.08
CSA MM/Inhofe	
2010	1.01
2015	1.15
2020	1.05
Jeffords/Carper	
2010	2.00
2015	1.79
2020	1.79

The total benefits for each interpolated/extrapolated scenario were calculated by summing the benefits from the estimated ozone reductions and the benefits from the estimated $PM_{2.5}$ reductions for each scenario in each model year.

EPA checked the ability of the extrapolation method to accurately estimate total health benefits by using the modeled results for the Inhofe scenario to predict the benefits for the two other modeled scenarios (Carper and CAIR/CAMR/CAVR). Extrapolated benefits for the CAIR/CAMR/CAVR scenario were identical to the modeled benefits, reflecting the overall similarity of the geographic distribution of emissions reductions under the two scenarios. This suggests that the extrapolated benefits for the CSA 2003 and CSA MM scenarios should be very good approximations to the benefits that would be estimated using direct air quality modeling. Extrapolated benefits for the Carper scenario were within 5.5% of the modeled benefits, which is a reasonable deviation, given the differences in the geographic distribution of emissions reductions between the Inhofe and Carper scenarios. EPA would expect the extrapolation from Carper to Jeffords to provide a better estimate because the difference in geographic distribution between the two scenarios is less than between Inhofe and Carper.